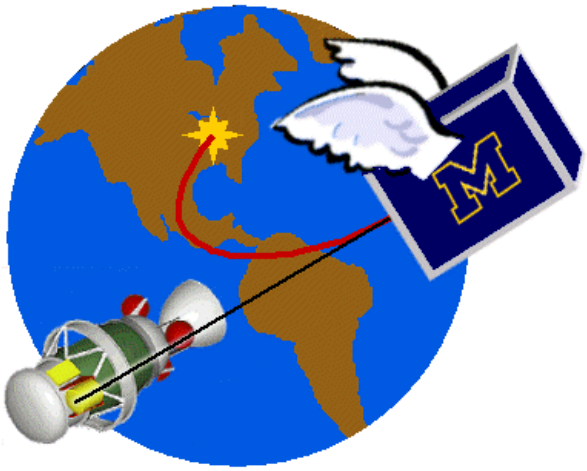
Icarus Student Satellite Project

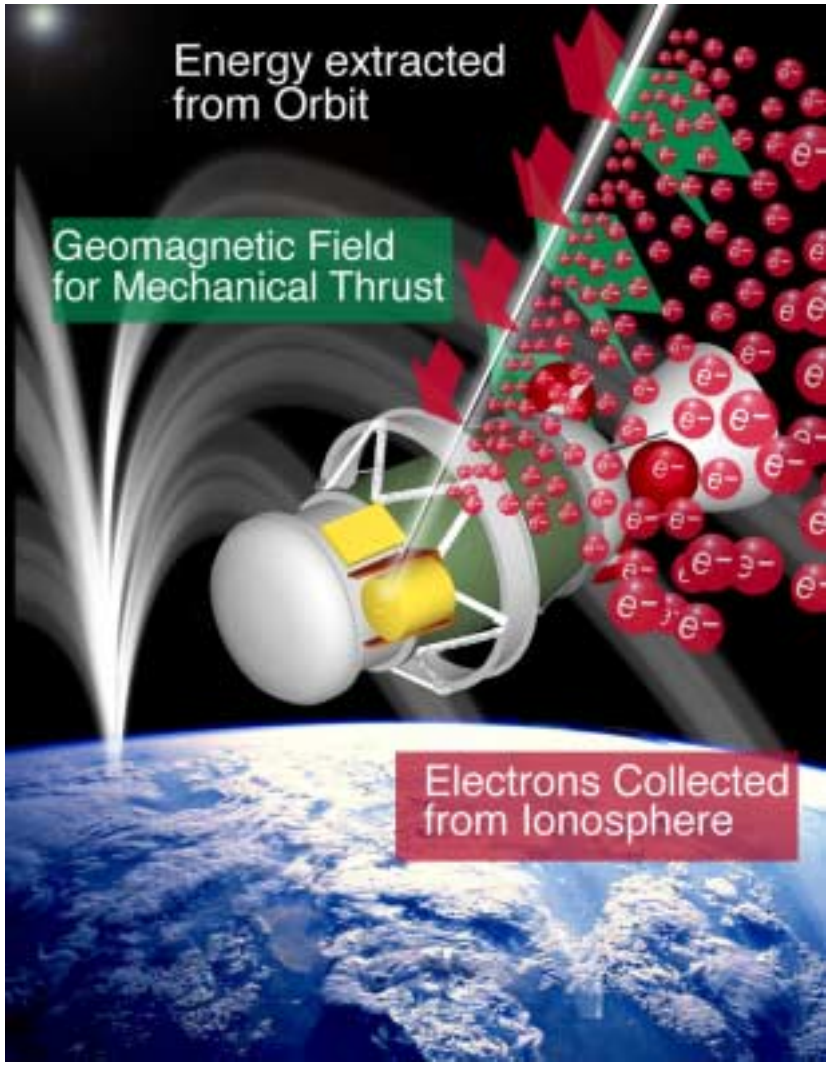


ICARUS

BT Cesul
Hannah Goldberg
Dr. Brian Gilchrist

Student Space System Fabrication Lab (S³FL)
University of Michigan, College of Engineering

Propellantless Space Propulsion Using Electrodynamic (ED) Tethers



- Space Tethers interacting with Earth's Magnetic Field and Ionosphere
  - Enables propellantless propulsion
    - capable of saving International Space Station > $1B in reboost costs
  - Currents driven through long (~5km) conducting tether in space generate highly efficient thrust.
- NASA's ProSEDS mission will demonstrate ED tether propulsion in '01
  - Michigan's Space Physics Research Laboratory (SPRL) providing
    - Plasma diagnostics instrument
    - High-Voltage control circuitry
  - Michigan's CoE/SPRL providing
    - Michigan's FIRST student built satellite!
    - Icarus is a small instrumented satellite placed at end of ProSEDS tether.
      - Collects and transmit data for tether and s/c dynamics

Mission Requirements

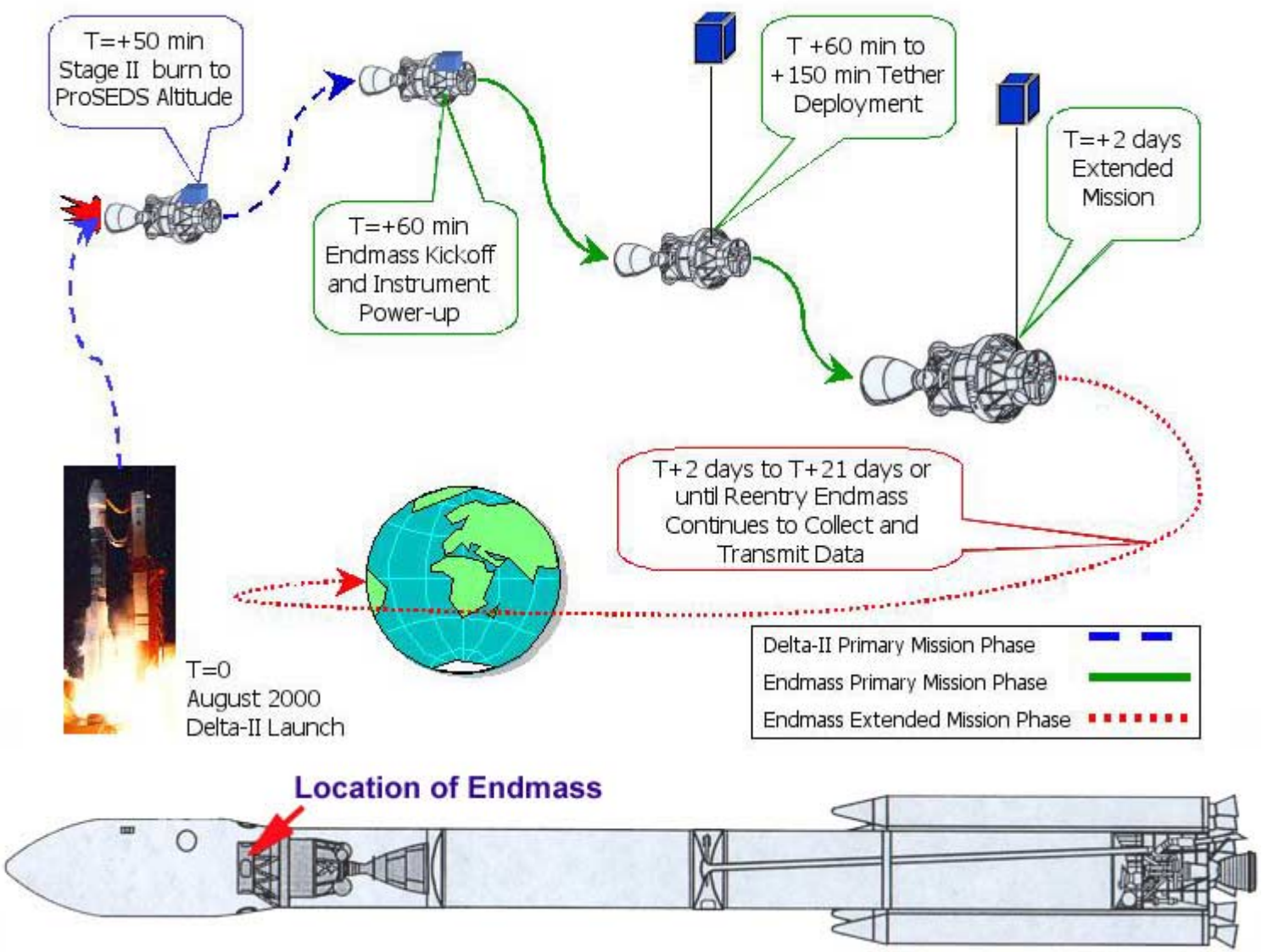
Endmass Mission Statement

- The Icarus spacecraft will:
  - Serve as an endmass to stabilize the ProSEDS tether
  - Collect and transmit tether dynamics and endmass attitude data
  - Not interfere with the Delta-II or ProSEDS primary mission objectives

Mission Lifetime

- Primary Mission - Day 1
  - The endmass is designed to operate with a 100% transmitter duty cycle for four orbits to ensure delivery of the data desired by ProSEDS
- Extended Mission - Up to 20 Additional Days On-orbit
  - The endmass is designed to operate at a 20% transmitter duty cycle for up to 21 days, at which time the NTIA licensing agreement requires permanent shutdown

Mission Timeline



Requirements

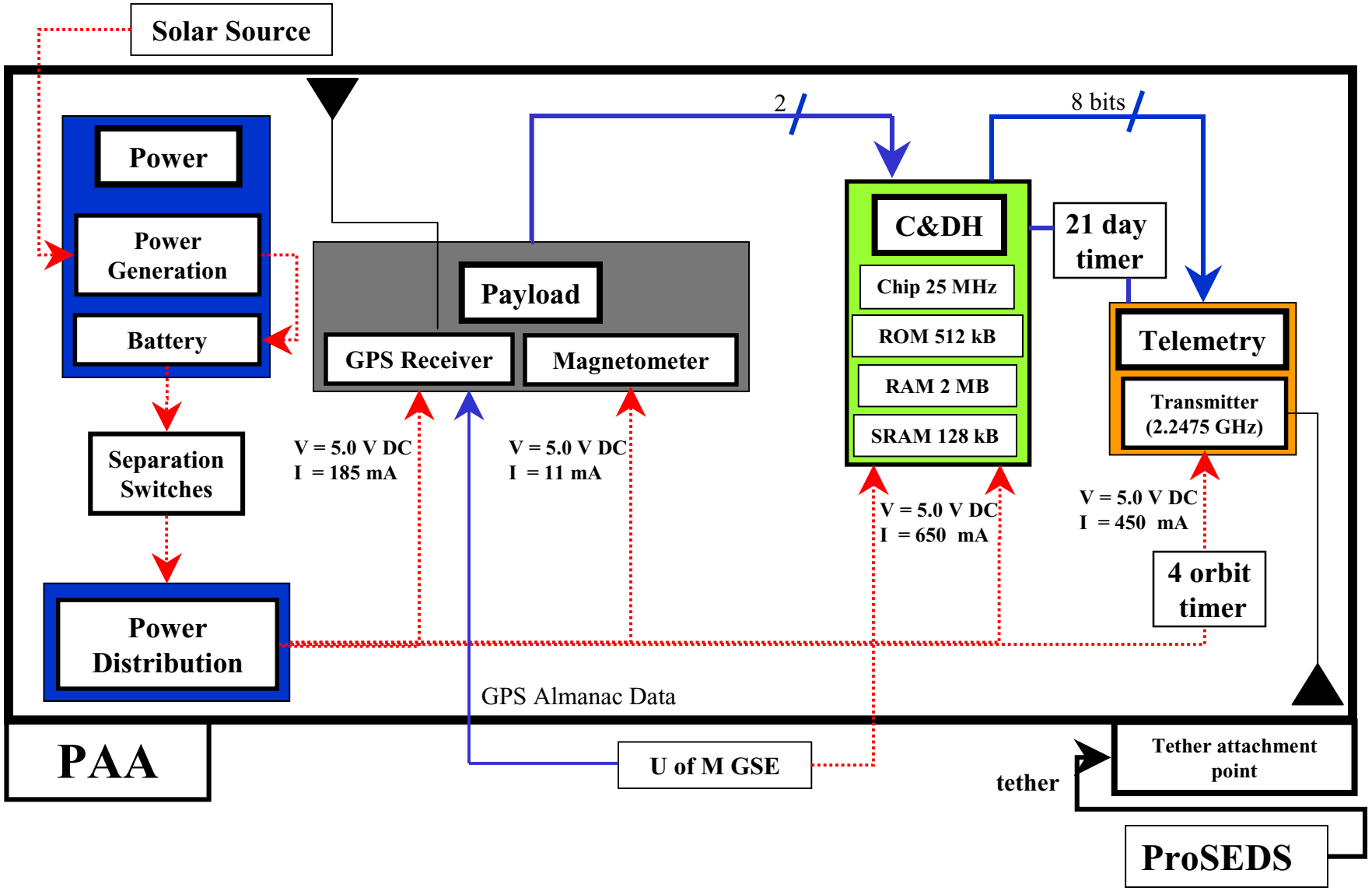
System Requirements

- Mass
  - 20.4 kg +/- 0.45 kg (including the attachment interface hardware)
- Payload
  - *Icarus* must contain a GPS unit to measure relative position
  - *Icarus* must contain a magnetometer to measure endmass attitude
- Transmission
  - The RF link capability must be disabled after 21 days to fulfill NTIA licensing agreement

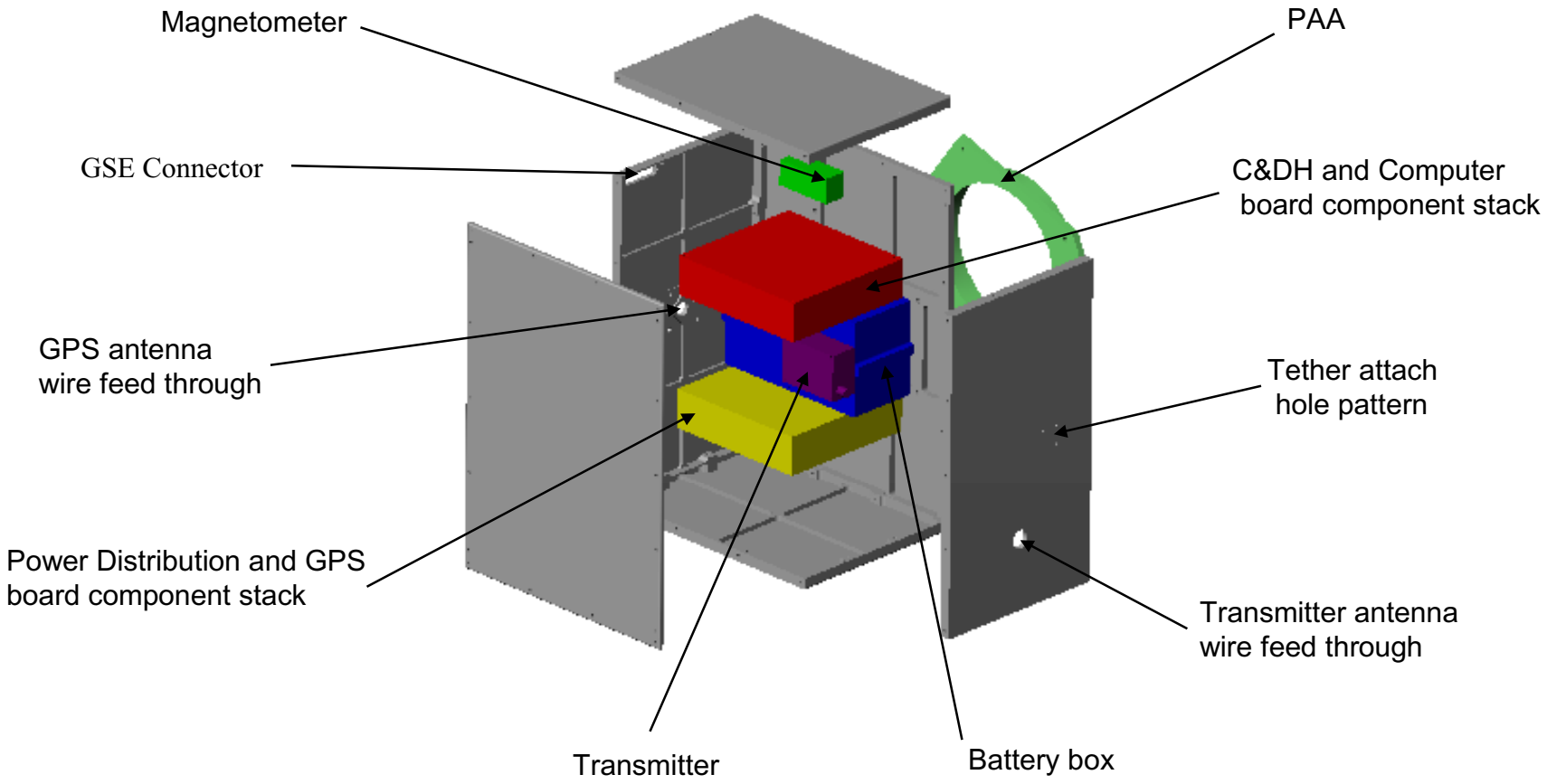
Functional Requirements

- Self-contained autonomous spacecraft
- Generate and store power for nominal spacecraft operation
- Store instrument data for transmission

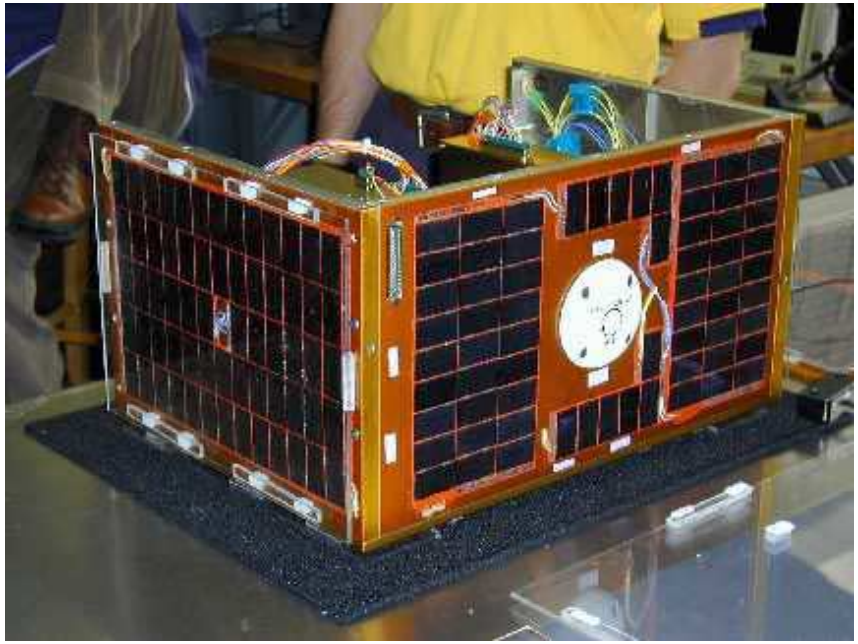
System Block Diagram

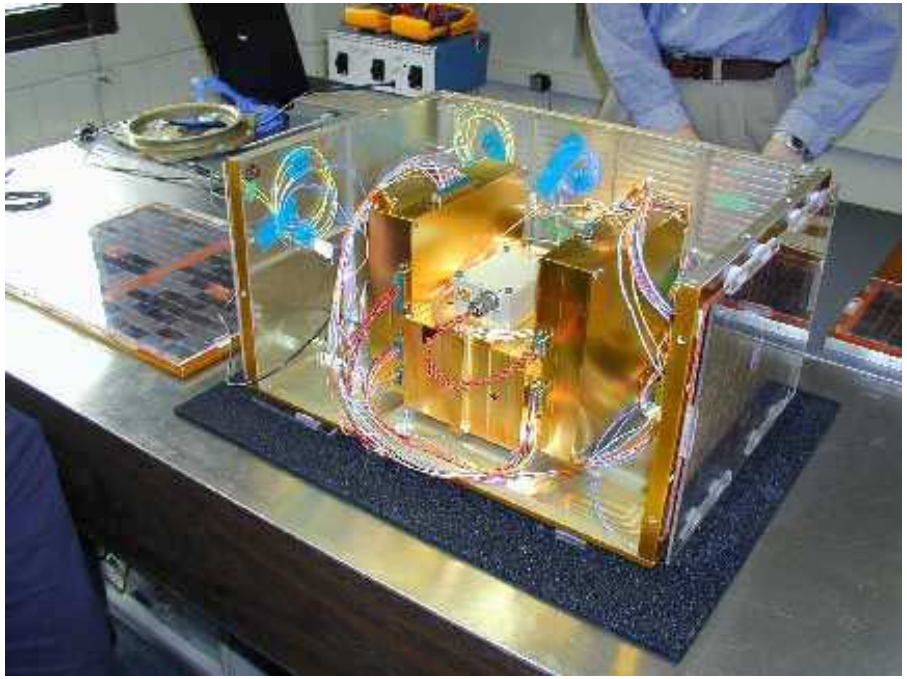


Structural Layout



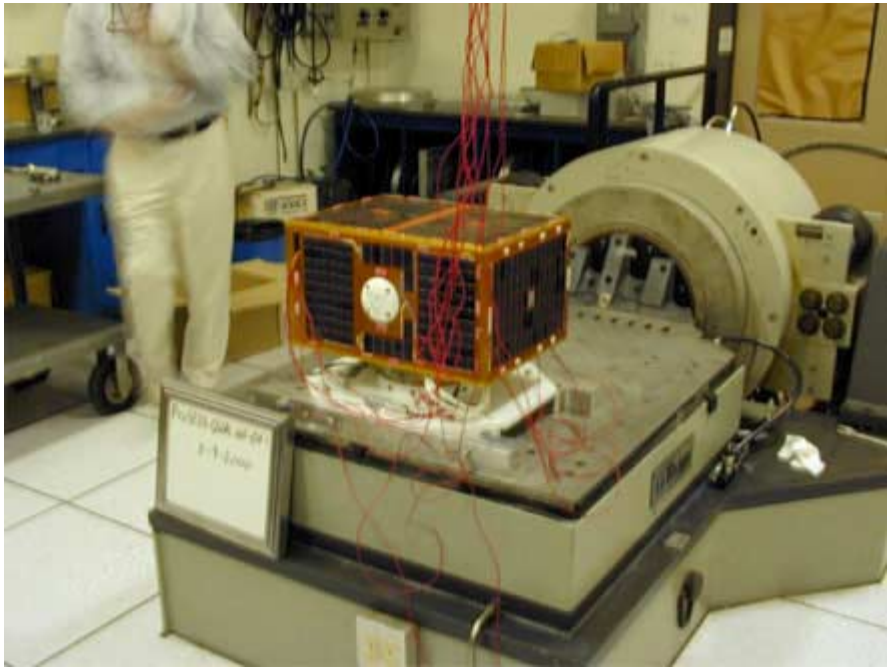
The Icarus Satellite





Icarus in Development

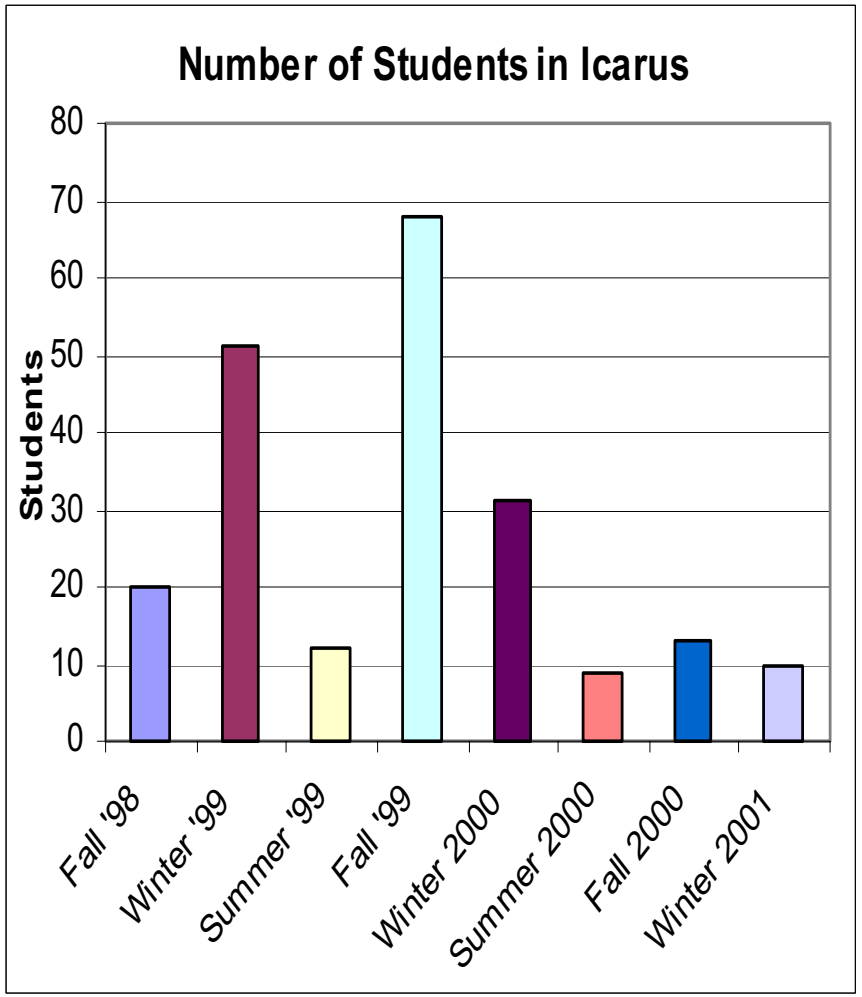
Students in Lab working on Icarus - Winter, 2000



Icarus at NASA/MSFC for Vibration Testing - May, 2000

Icarus Project Involvement

- Heavily Student Managed, Designed, and Manufactured
  - Student Project Manager, Business Manager, and Chief Engineer
  - Student Subsystem Teams
  - Post-doc and engineering support for some critical tasks
- Graduate and Undergraduate Students
  - Aero, EE, CompE, ME, ChE, IOE, AOSS, Physics
- Faculty and Staff Engineering Mentorship
  - Faculty Principal Investigator
  - Engineering Project Manager from Space Physics Research Laboratory (SPRL)
    - provided day-to-day oversight
  - Mentor Engineers for Subsystems (e.g. instruments, structures, etc.)
  - Faculty Technology Advisors
- NASA-MSFC
  - Engineering Mentorship, design reviews
  - Environmental Testing



Lessons Learned

- Tremendous Experience for Students
  - Students are come out of the Icarus experience wiser beyond their years
    - Practical skills
    - Teamwork
    - Realism
- NASA achieves
  - Strong out-reach program
  - Potential for additional science at less cost
- Close cooperation with Professional Staff/Faculty essential
  - At times students operate highly independently. Other times, role was more of an apprenticeship. Both are appropriate
- Short tenure of students is a challenge
  - Good mix of Grad and under-grad students essential